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Mercury in Wetlands on the Lostwood National Wildlife Refuge, North Dakota

- A cooperative effort between the North Dakota Department of Health, USEPA, USFWS, and USGS

Why are we doing this study?

- ND and EPA pursuing wetland research
- Wetlands are active sites for mercury methylation
- No known comprehensive studies of mercury in Prairie Pothole wetlands
- Prairie Pothole wetlands and inundation patterns
- LNWR location relative to point sources

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Synoptic-Survey Project Objectives

- Determine Hg and related constituents in wetland water and bed sediments
- Evaluate mercury/wetland type relations
- Evaluate mercury/water-quality relations

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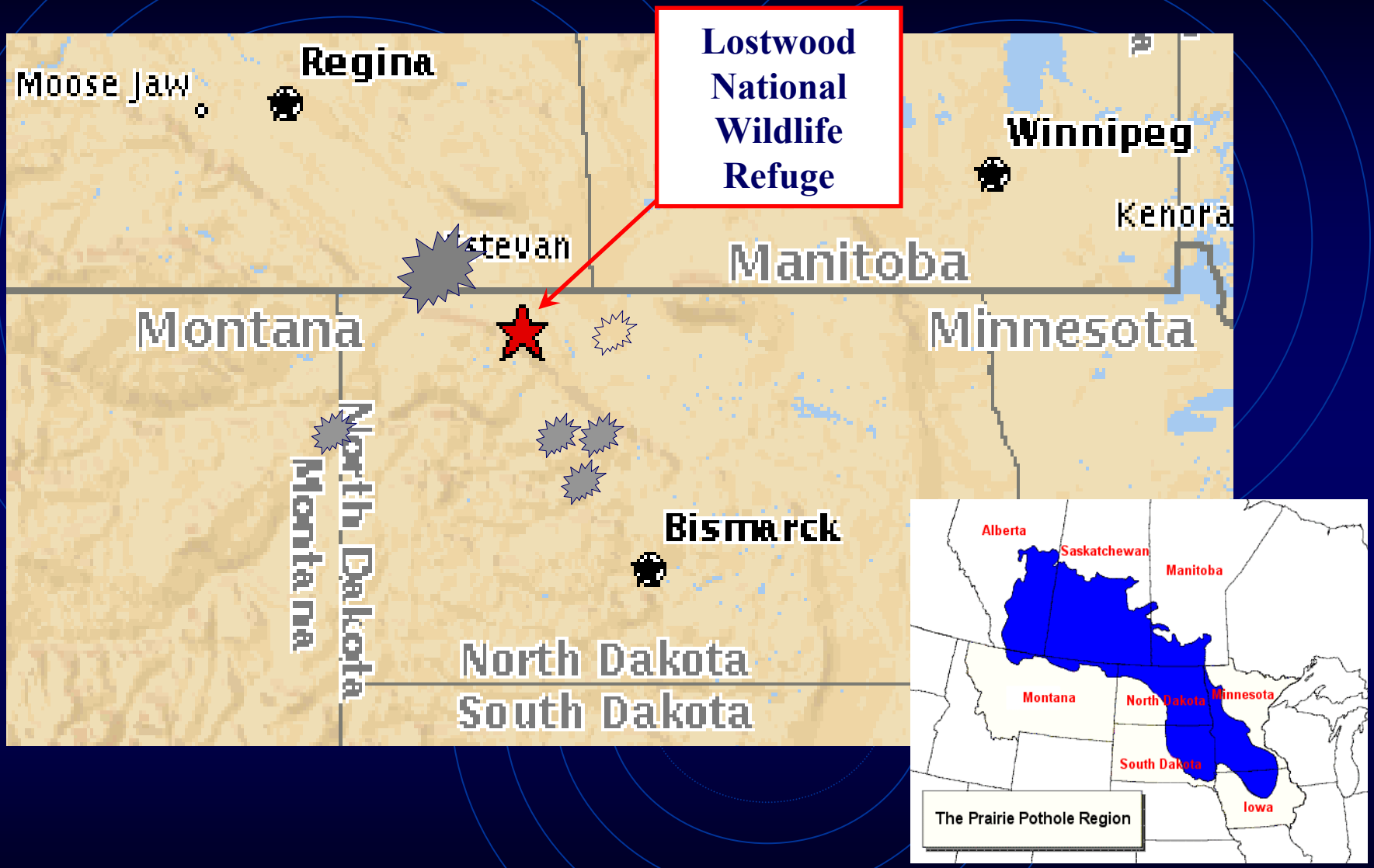
Study Area



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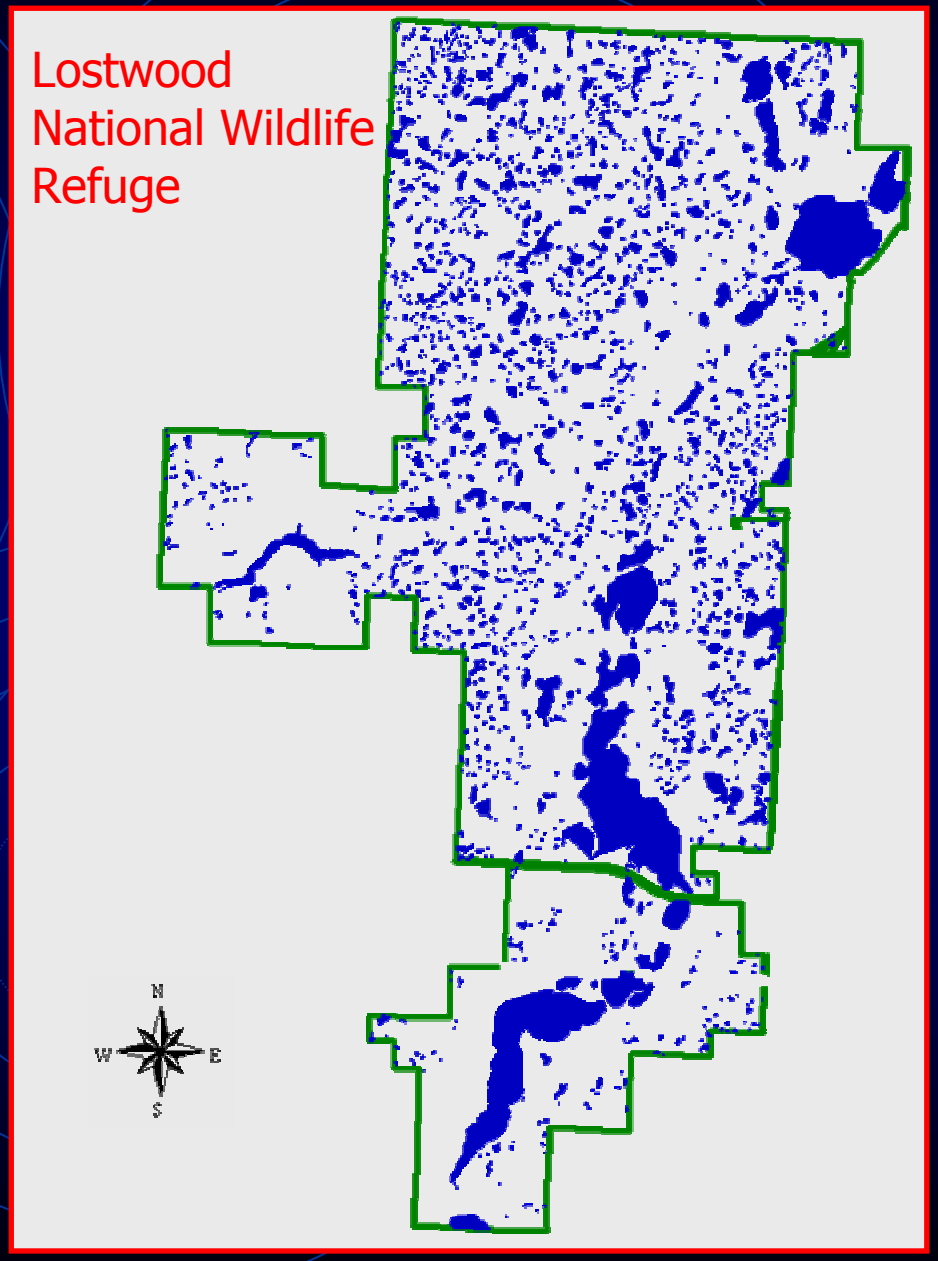
Study Area



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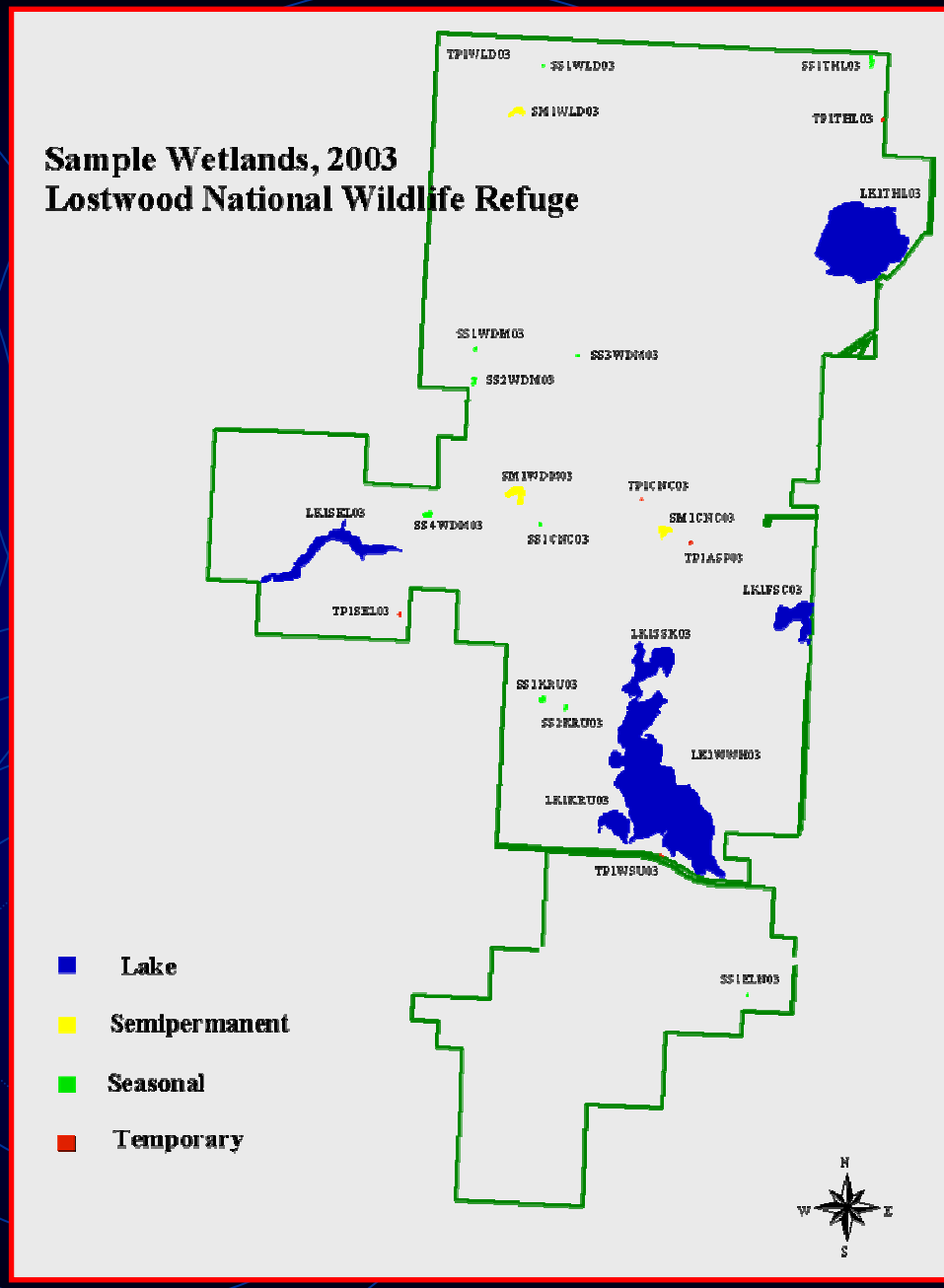
Sampling Design

- 24 wetlands sampled in 2003
- 6 wetlands each in 4 wetland types
- Temporary
- Seasonal
- Semi-permanent
- Permanent



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Mercury Methylation

- By-product of bacterially-mediated sulfate reduction
- Sulfate reduction requires:
    1) Anoxia
    2) Adequate organic carbon
    3) Adequate sulfate
- Inorganic mercury must be in an appropriate form
- Bioavailability of inorganic mercury influenced by:
    1) pH
    2) Sulfate concentration

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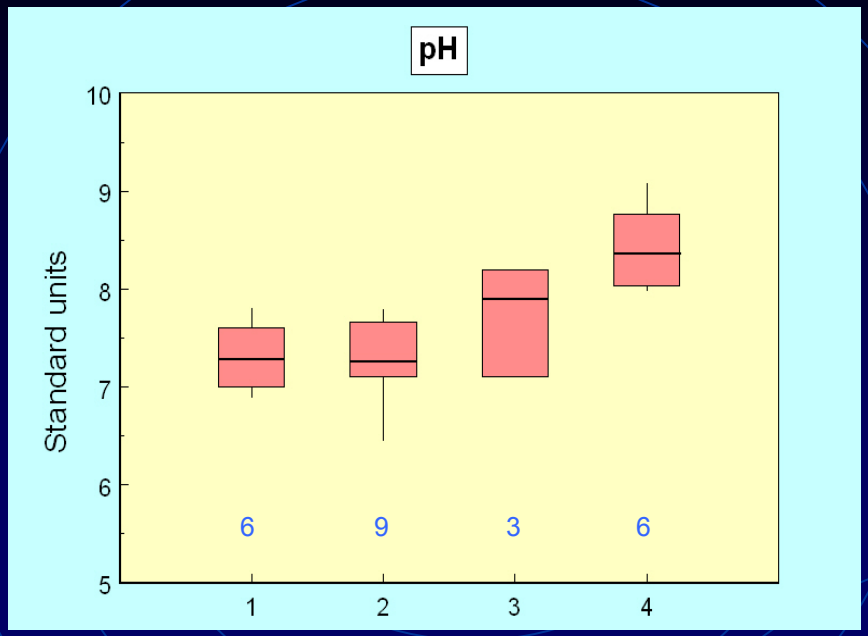
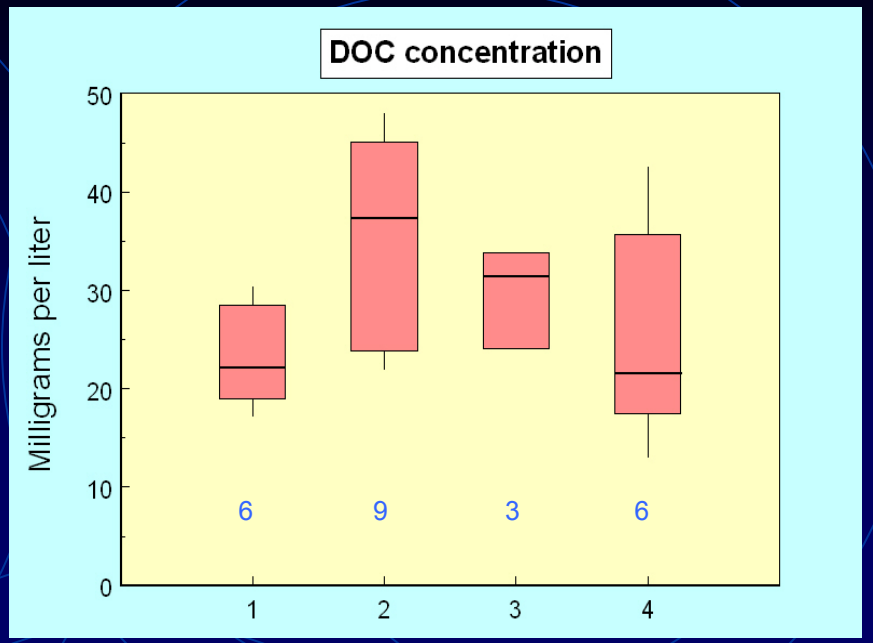
General Water-Quality Characteristics of the Wetlands





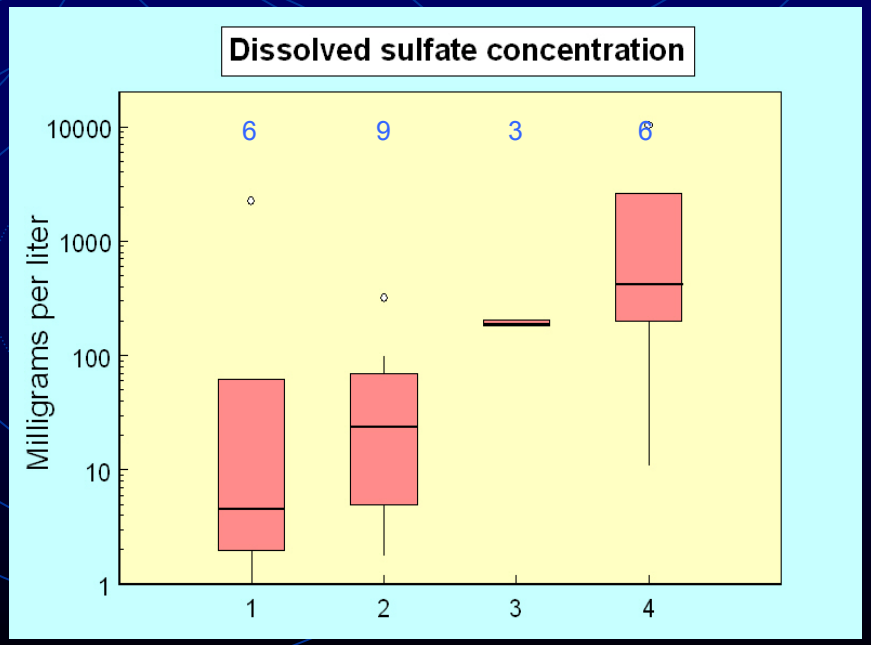
Wetland Type

1 = Temporary

2 = Seasonal

3 = Semi-permanent

4 = Permanent Lake



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Summary of General Water-Quality Characteristics

- Prairie Pothole wetland QW driven by:
  1) Surface-/ground-water interactions
  2) Frequency/duration of inundation
  3) Vegetation regime
- Large variability in pH, dissolved organic carbon, and sulfate concentrations

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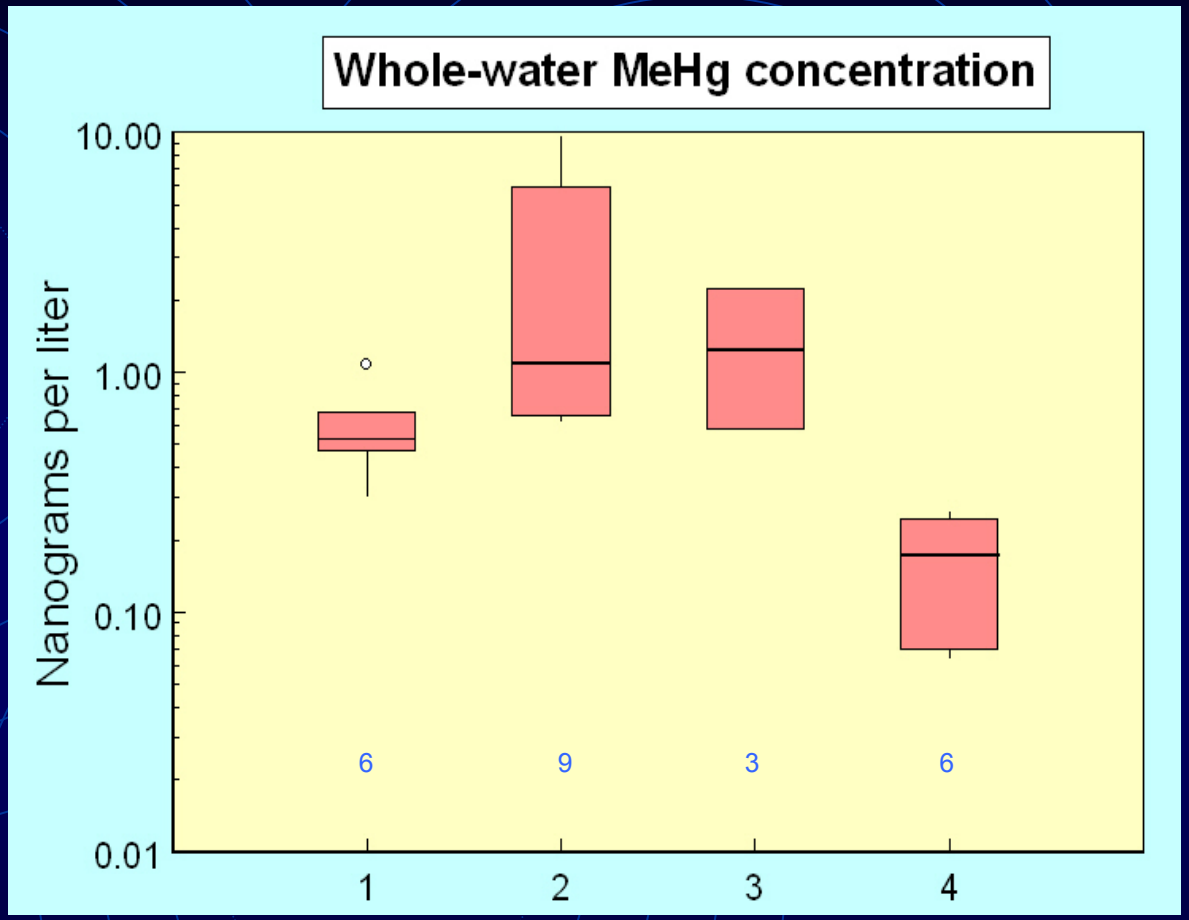
MeHg in the Wetlands (Water Column)



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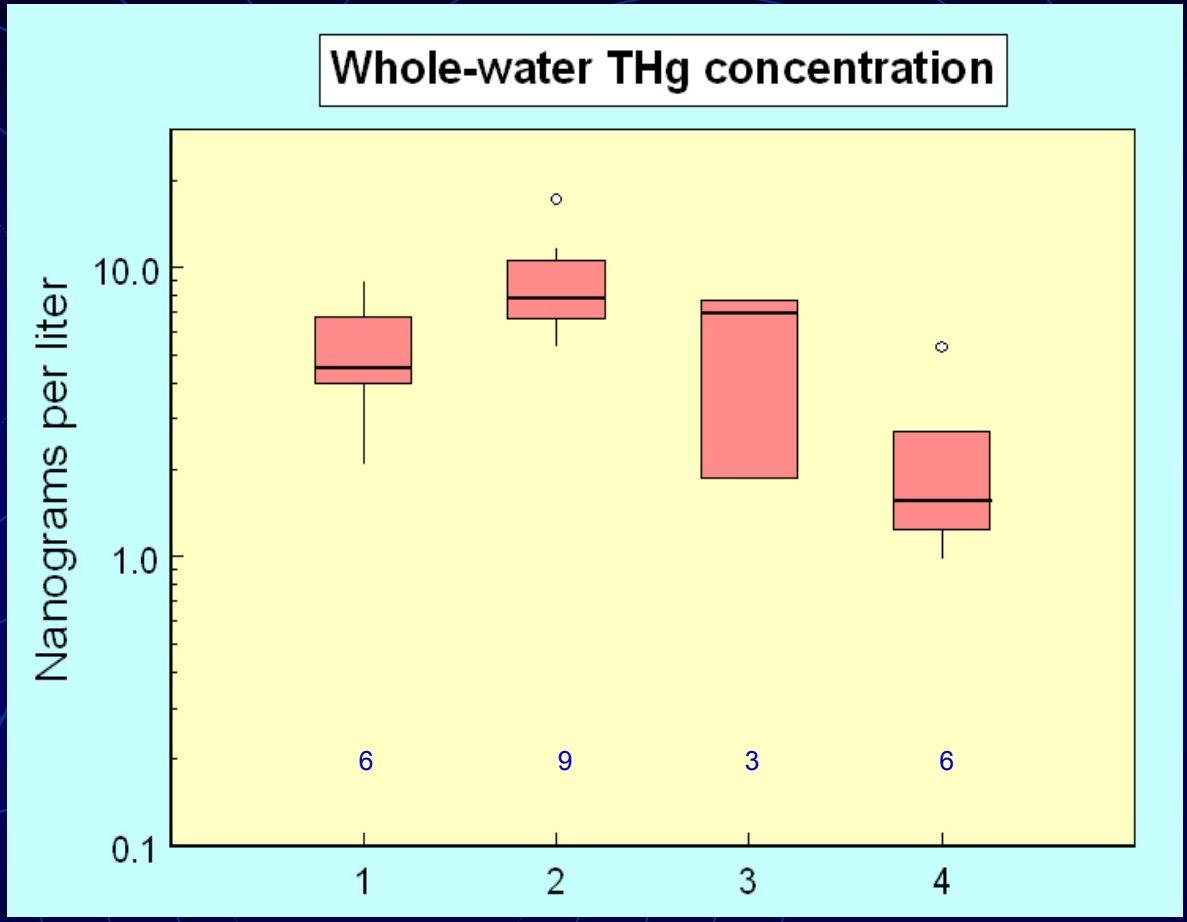
THg in the Wetlands (Water Column)



Wetland type

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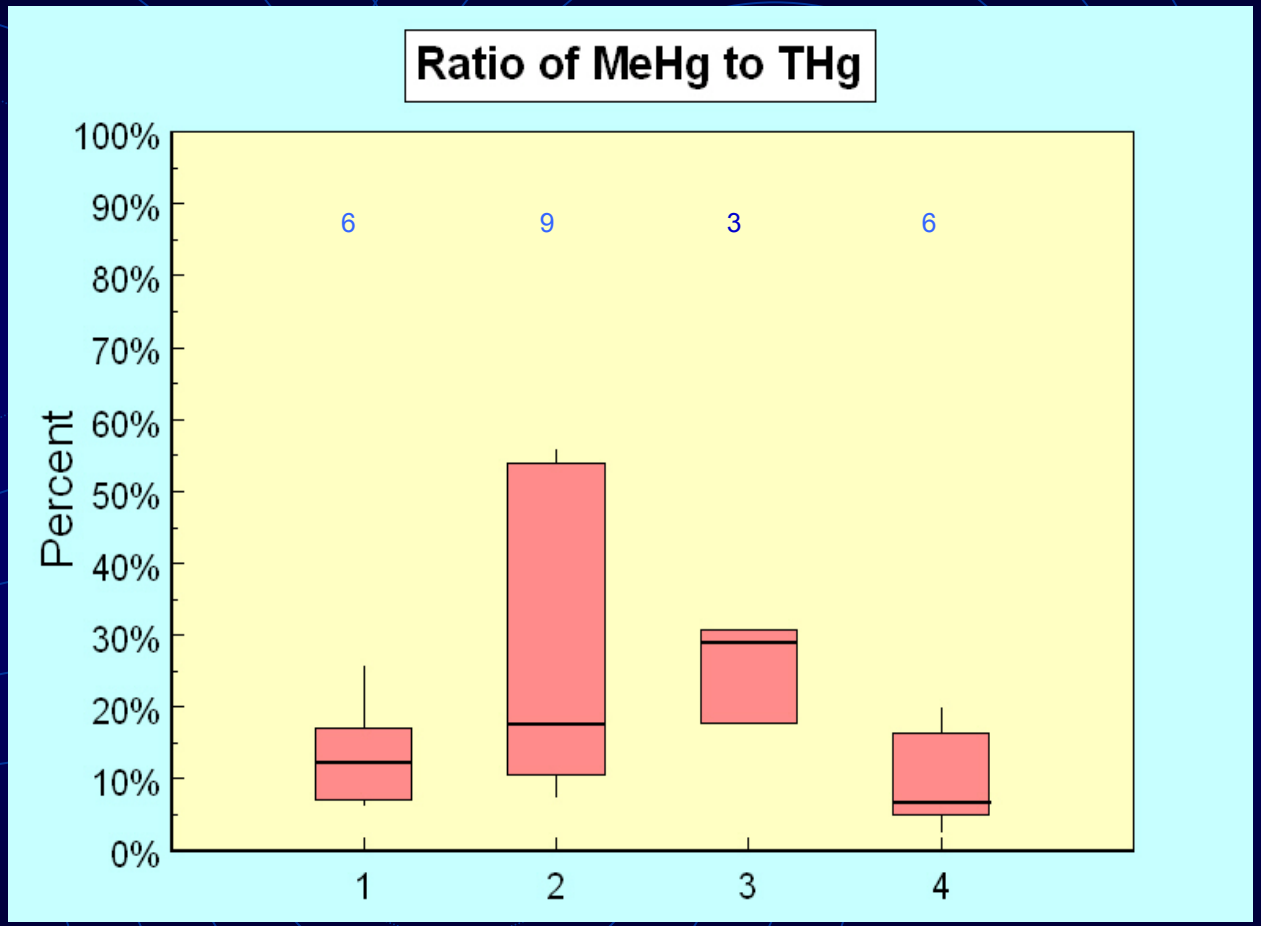
Ratio of MeHg/THg in the Wetlands (Water Column)



Wetland type

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Summary of Mercury in the Water Column of the Wetlands

- MeHg concentrations in the wetlands are very high; maximum of **9.56** ng/L
- **Seasonal** and **semi-permanent** wetlands generally have highest MeHg
- THg concentrations not extremely high
- Seasonal and semi-permanent wetlands average MeHg/THg ratio about **30%**

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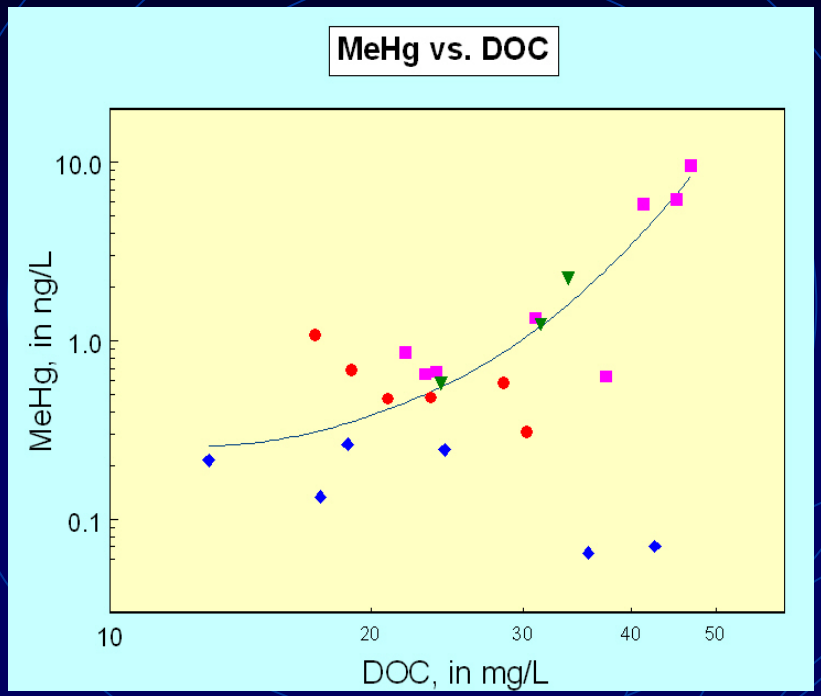
MeHg Versus DOC (Water Column)

All wetlands combined

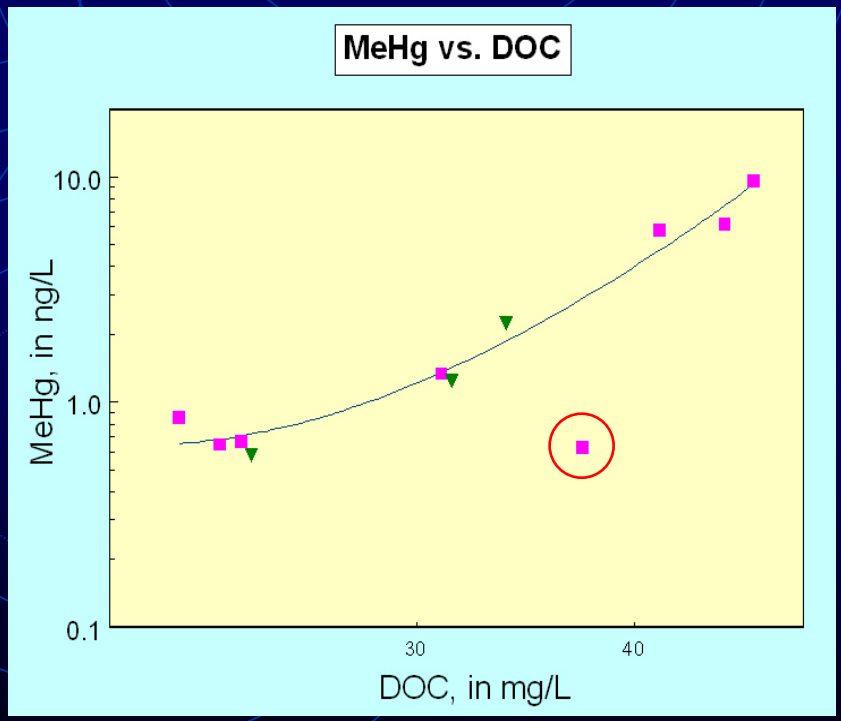


Explanation

- Temporary wetlands
- Seasonal wetlands
- Semi-permanent wetlands
- Permanent lake wetlands

Higher MeHg associated with higher DOC (>30 mg/L)

Seasonal and semi-permanent wetlands only



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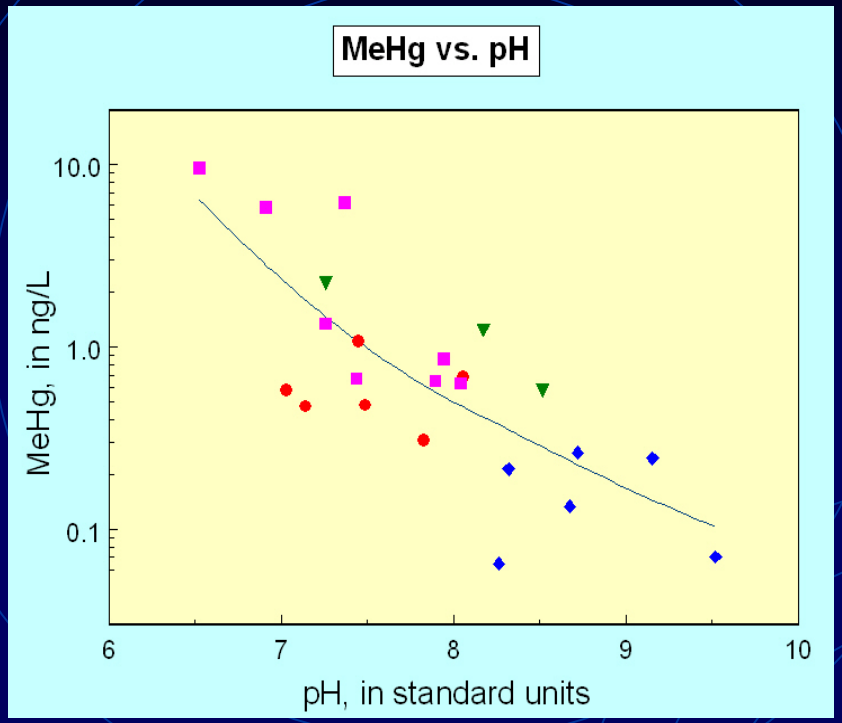
MeHg Versus pH (Water Column)

All wetlands combined

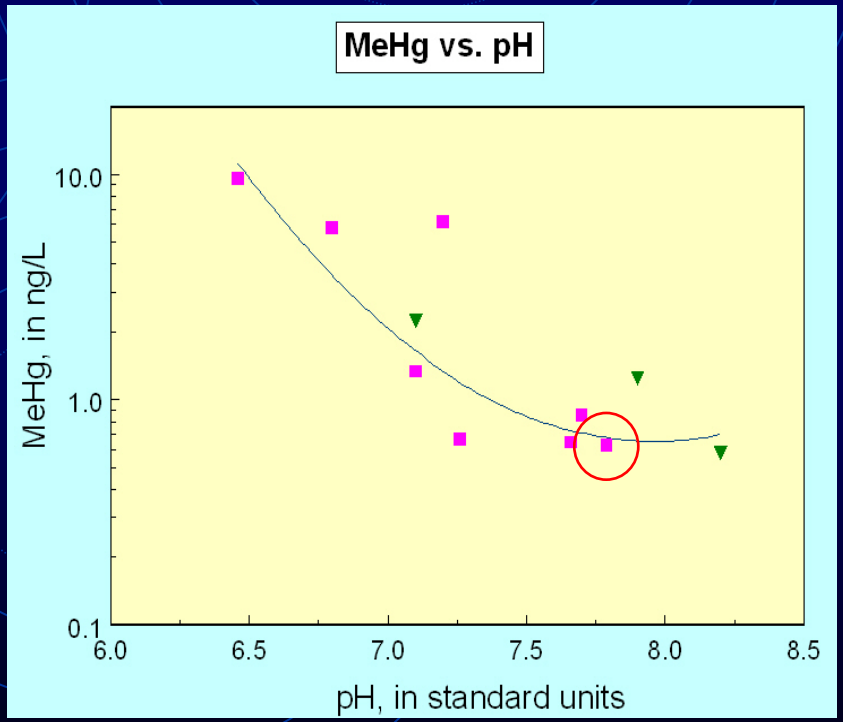


Explanation

- Temporary wetlands
- Seasonal wetlands
- Semi-permanent wetlands
- Permanent lake wetlands

Higher MeHg associated with lower pH (<7.5)

Seasonal and semi-permanent wetlands only



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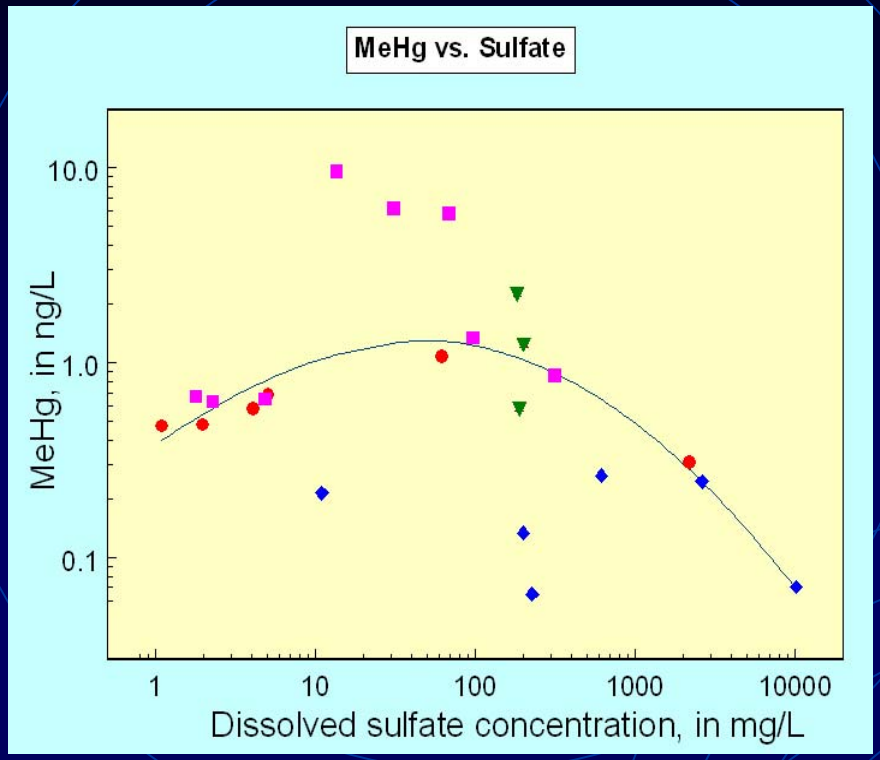
MeHg Versus Sulfate (Water Column)

All wetlands combined

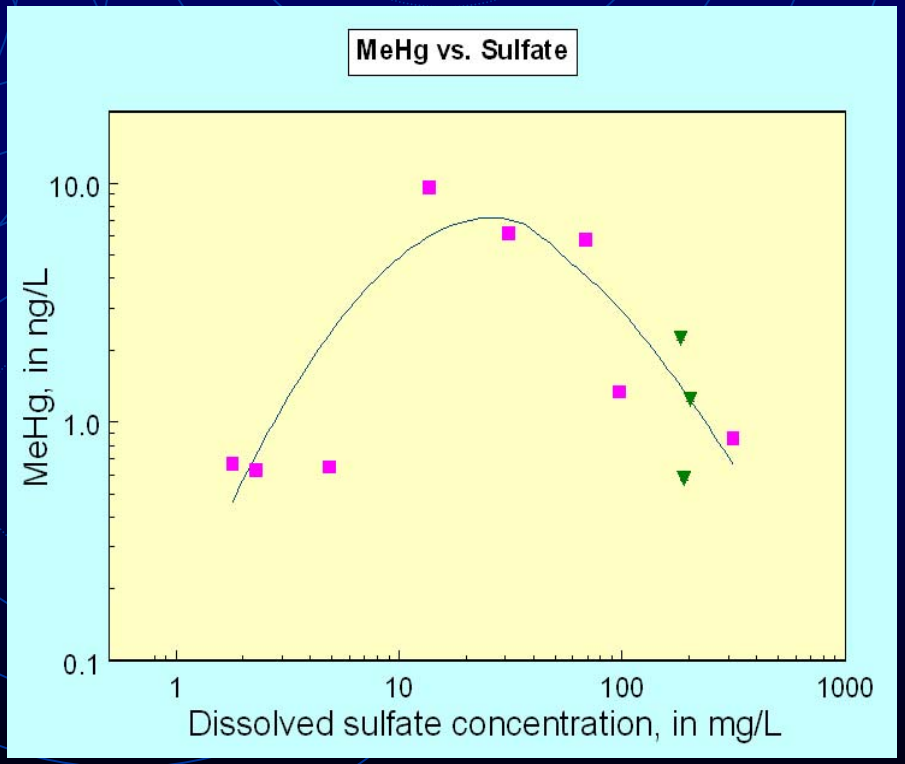


Explanation

- Temporary wetlands
- Seasonal wetlands
- Semi-permanent wetlands
- Permanent lake wetlands

Highest MeHg associated with sulfate >10 and <100 mg/L

Seasonal and semi-permanent wetlands only



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Summary of Synoptic-Survey Preliminary Findings

- Seasonal and semi-permanent wetlands have very high MeHg
- Hydrologic and vegetation characteristics make these wetlands ideal sites for mercury methylation
- Primary contributing factors include:
  1) Dissolved organic carbon > 30 mg/L
  2) pH < 7.5
  3) Sulfate between 10 to 100 mg/L

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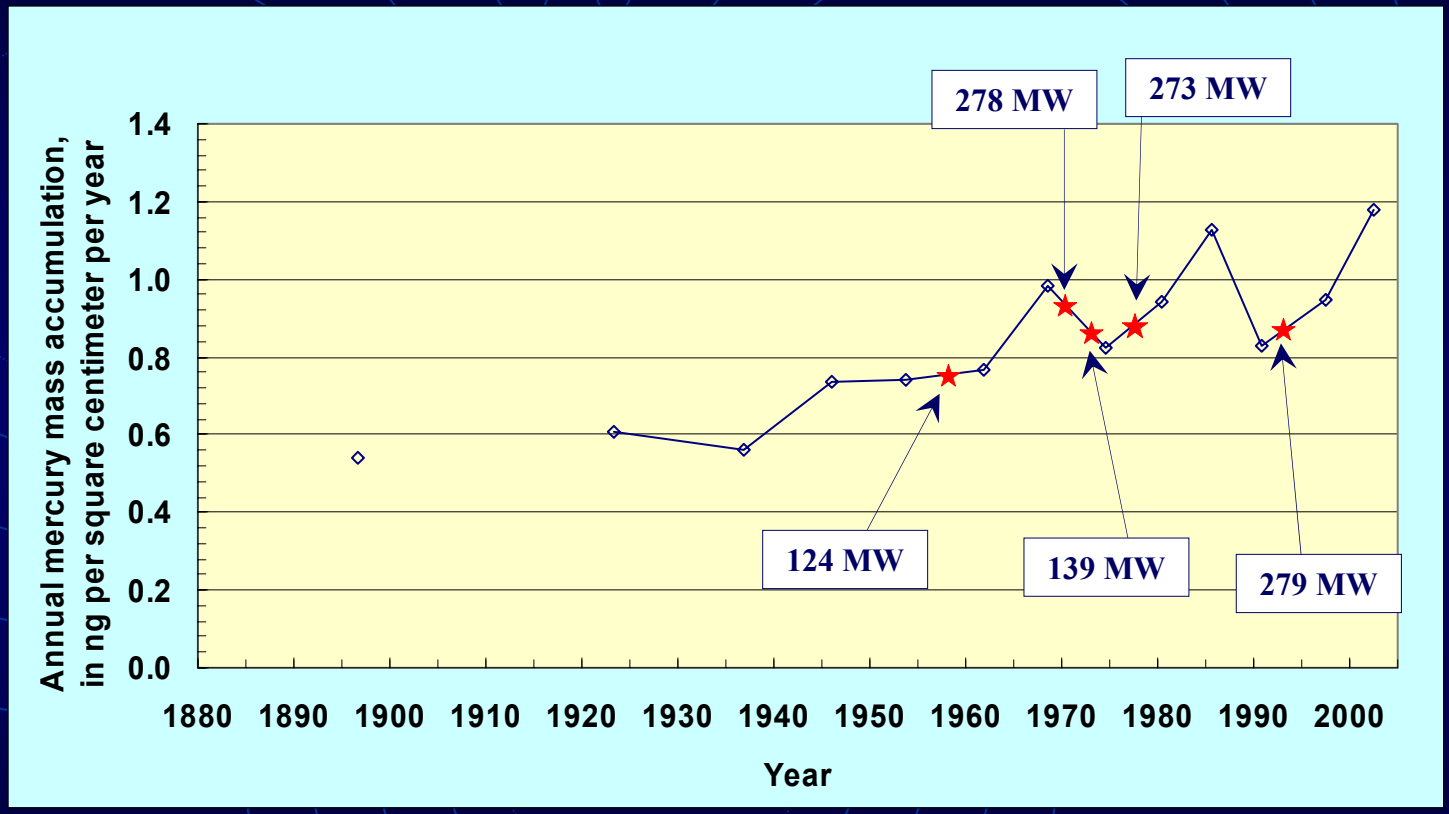
Historic Mercury Deposition and Estevan Power-Plant Developments

- Sediment core collected from permanent wetland
- 1-cm vertical segments analyzed for THg and Pb-210 age dating



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Summary

- Preliminary results for on-going comprehensive study of THg/MeHg in LNWR wetlands
- Controls on MeHg concentrations in LNWR wetlands (primarily pH, DOC, sulfate) are similar to findings of previous investigations
- Seasonal and semi-permanent wetlands are ideal sites for mercury methylation
- Historic deposition of THg in bed sediment appears to reflect developments at the Estevan power facility

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Acknowledgements

- Mike Ell, North Dakota Health Department
- Kathy Hernandez, USEPA
- Dave Krabbenhoft, USGS
- Gregg Wiche, USGS
- Kevin Johnson, USFWS
- Chris Fuller, USGS

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Overall Study Objectives

- Perform a comprehensive study of occurrence of mercury in LNWR wetlands
- Investigate THg/MeHg processes in a number of ecosystem components of wetlands including:
  1) Water
  2) Bed sediment
  3) Biota
  4) Atmosphere
- Evaluate potential for MeHg production and biological exposure in LNWR wetlands
- Investigate historic mercury deposition patterns
- Investigate source-receptor relations for atmospheric mercury

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Constituents Analyzed

Field-measured constituents and properties
Dissolved oxygen concentration
pH
Specific conductance
Water temperature
Turbidity

Dissolved major-ion constituents
Calcium
Magnesium
Potassium
Sodium
Alkalinity
Chloride
Sulfate
Dissolved solids (sum of constituents)

Dissolved trace-element constituents
Aluminum
Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Nickel
Selenium
Silver
Thallium
Zinc

Dissolved and whole-water mercury constituents
Dissolved methylmercury
Particulate methylmercury
Whole-water methylmercury
Dissolved total mercury
Particulate total mercury
Whole-water total mercury

Dissolved and whole-water organic-carbon constituents and suspended solids
Dissolved organic carbon
Whole-water organic carbon
Whole-water suspended solids

Bed-sediment constituents
Percent dry weight
Loss-on-ignition (percent)
Methylmercury (dry weight)
Total mercury (dry weight)

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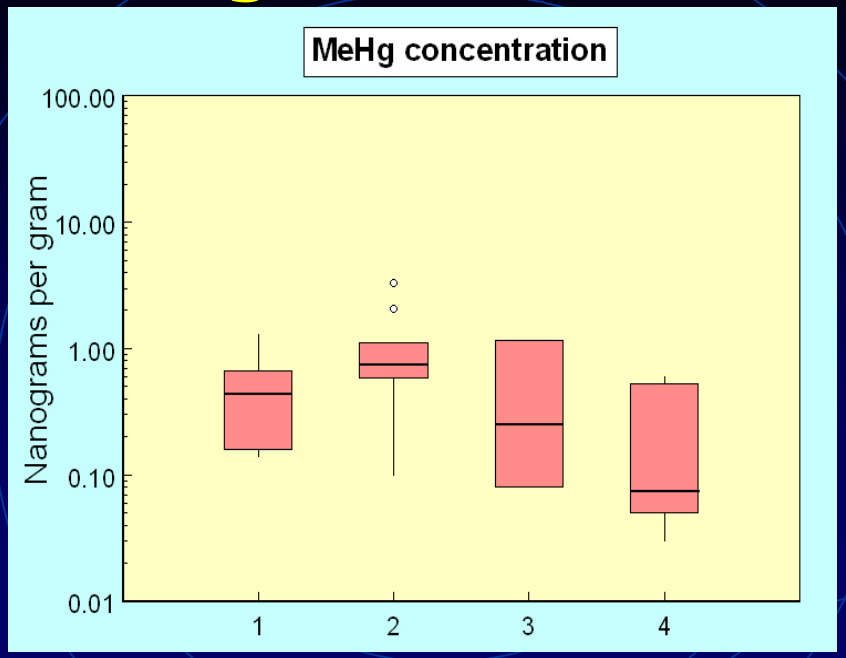
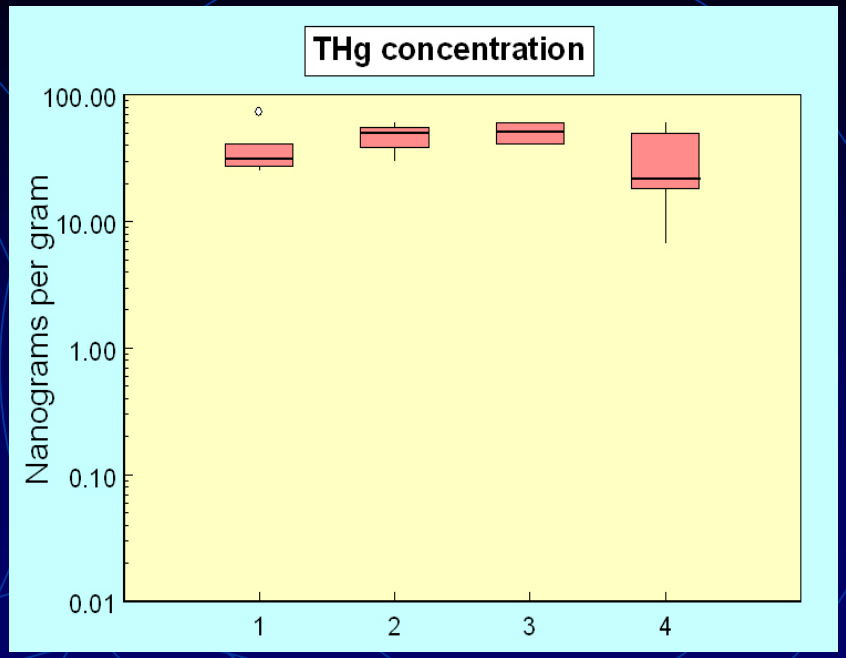
Hg in Bed Sediments of the Wetlands





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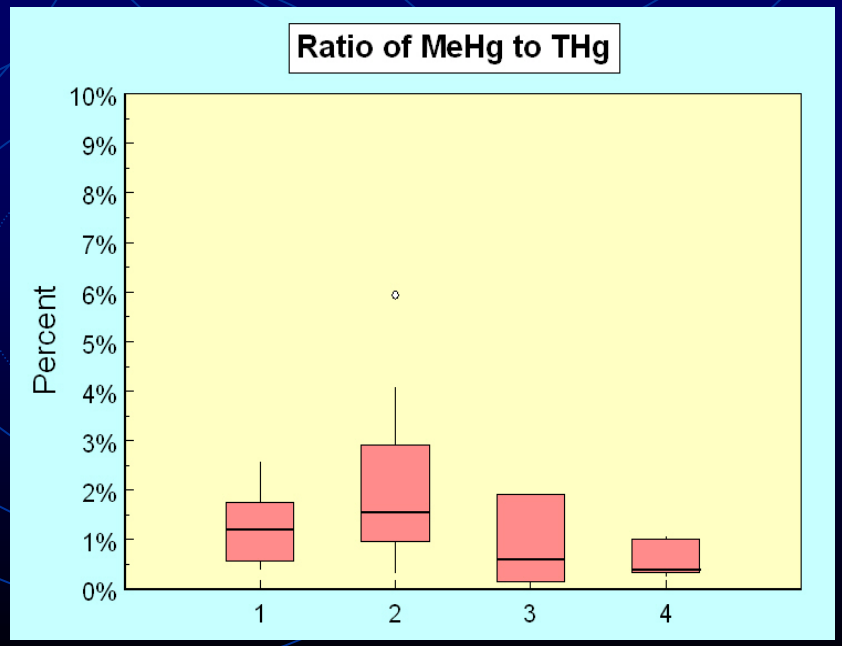

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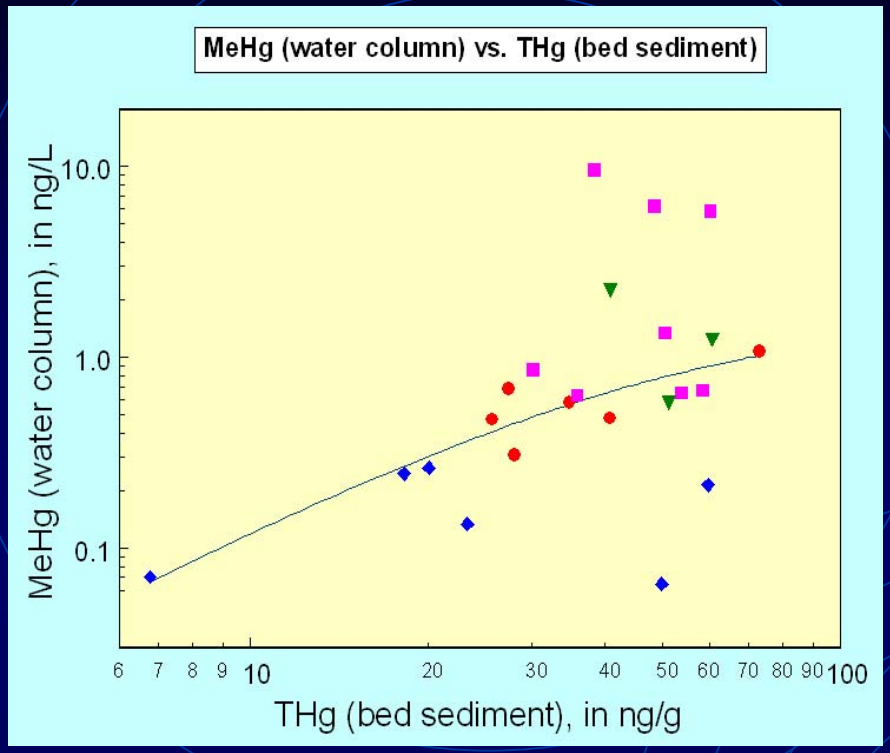
MeHg (Water Column) Versus THg (Bed Sediment)

All wetlands combined



Explanation

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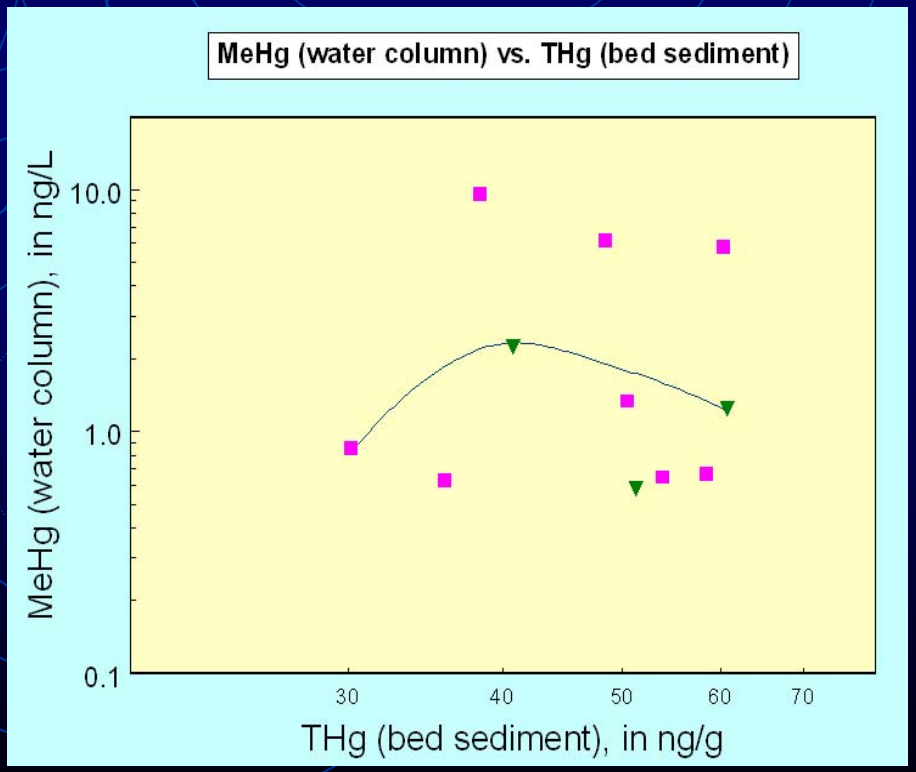
- Seasonal wetlands
- Semi-permanent wetlands
- Permanent lake wetlands

Higher MeHg associated with bed-sediment THg>35 ng/g

Seasonal and Semi-permanent wetlands only



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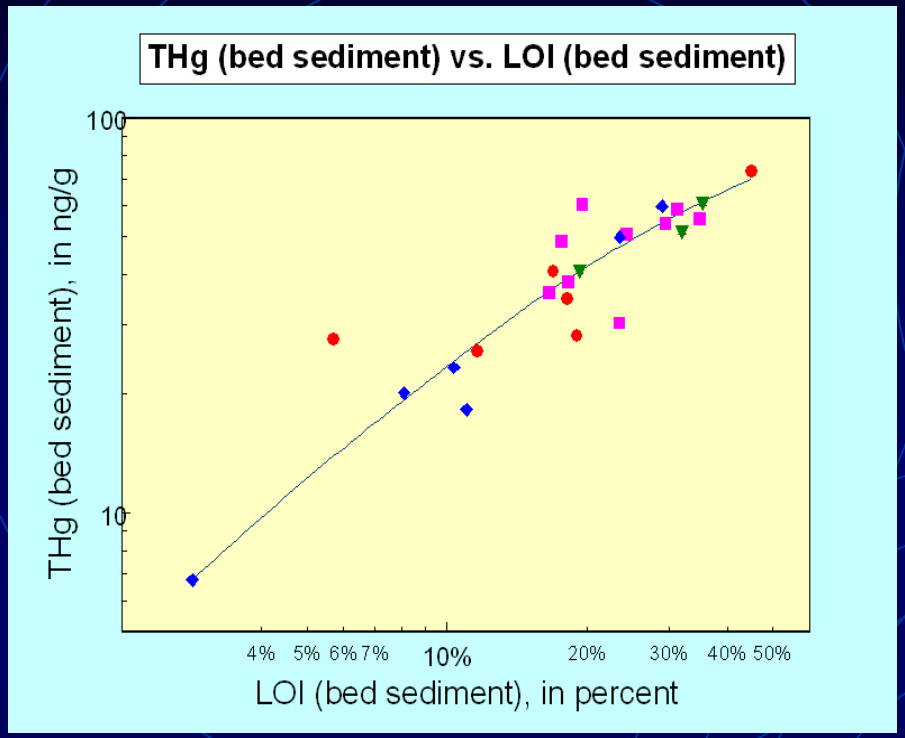
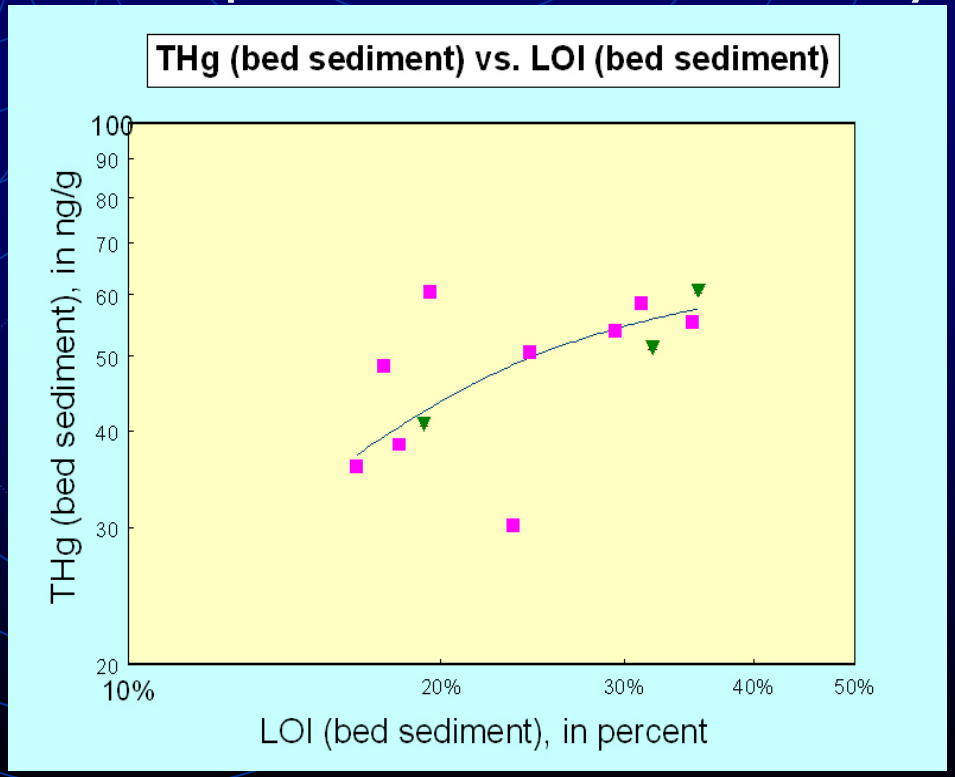
THg versus loss-on-ignition (bed sediment)

All wetlands combined



Organic content of bed sediments affects accumulation of THg in bed sediments

Seasonal and Semi-permanent wetlands only



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